basic education

Department:
Basic Education
**REPUBLIC OF SOUTH AFRICA**

**NATIONAL
SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY: AUTOMOTIVE**

**NOVEMBER 2019**

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 14 pages and a 2-page formula sheet.**

**INSTRUCTION AND INFORMATION**

1.      Write your centre and examination numbers on the ANSWER BOOK.

2.      Read ALL the questions carefully.

3.      Answer ALL the questions.

4.      Number the answers correctly according to the numbering system used in this question paper.

5.      Start EACH question on a NEW page.

6.      Show ALL calculations and units. Round off final answers to TWO decimal places.

7.      Candidates may use non-programmable scientific calculators and drawing instruments.

8.      The value of gravitational acceleration should be taken as 10 $m/s^2$.

9.      All dimensions are in millimetres, unless stated otherwise in the question.

10.     Write neatly and legibly.

11.     A formula sheet is attached at the end of the question paper.

12.     Use the criteria below to assist you in managing your time.

| QUESTION | CONTENT | MARKS | TIME in minutes |
|---|---|---|---|
| | **GENERIC** | | |
| 1 | Multiple-choice questions | 6 | 6 |
| 2 | Safety | 10 | 10 |
| 3 | Materials | 14 | 14 |
| | **SPECIFIC** | | |
| 4 | Multiple-choice questions | 14 | 10 |
| 5 | Tools and Equipment | 23 | 20 |
| 6 | Engines | 28 | 25 |
| 7 | Forces | 32 | 25 |
| 8 | Maintenance | 23 | 20 |
| 9 | Systems and Control (Automatic Gearbox) | 18 | 20 |
| 10 | Systems and Control (Axles, Steering Geometry and Electronics) | 32 | 30 |
| | **TOTAL** | **200** | **180** |

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)**

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.6) in the ANSWER BOOK, e.g. 1.7 E.

1.1     The workplace is organised by national policies and procedures dealing with HIV/Aids. What is the purpose of this code of practice?

    A     The act on safety states that all employers must make sure that the workplace is safe and that employees are not at risk of becoming ill or injured at work.
    B     The act contains common guidelines on how employers, employees and trade unions should respond to HIV/Aids in the workplace.
    C     Employers may not demote or promote an employee based on his/her HIV/Aids status.
    D     Employers can dismiss a person who is infected with HIV/Aids.     (1)

1.2     During which ONE of the following work processes do you have to wear a helmet to prevent harmful ultra violet rays?

    A     Lathe work
    B     Angle grinding
    C     MIG/MAGS welding
    D     Drilling     (1)

1.3     Which ONE of the following describes a workshop layout?

    A     Process layout
    B     Drill layout
    C     Inspection layout
    D     Receiving layout     (1)

1.4     Which heat treatment process is used to increase the surface hardness of a steel shaft?

    A     Annealing
    B     Tempering
    C     Case hardening
    D     Normalising     (1)

1.5     The purpose of hardening steel is to …

    A     increase the resistance against denting.
    B     increase the toughness.
    C     soften it.
    D     improve the welding results.     (1)

1.6    Which ONE of the following tests can be classified as a non-destructive test?

     A    Bend
     B    Machinability
     C    X-ray
     D    Nick-break    (1)
     **[6]**

## QUESTION 2: SAFETY (GENERIC)

2.1    State ONE important safety rule that should be adhered to before any machine in the mechanical workshop is switched on.    (1)

2.2    Give ONE reason why you need to clamp down a small work piece before any drilling is done.    (1)

2.3    State TWO safety rules you should observe before a hydraulic press is used.    (2)

2.4    Give TWO reasons why you have to use surgical gloves when treating a co-worker with open wounds.    (2)

2.5    State TWO safety precautions that must be taken into consideration for the safe handling of portable electrical equipment.    (2)

2.6    State ONE responsibility of an **employer** regarding safety in the work place.    (1)

2.7    State ONE responsibility of an **employee** regarding safety in the work place.    (1)
     **[10]**

## QUESTION 3: MATERIALS (GENERIC)

3.1    Explain how you will prevent damage to a file when conducting a filing test on a hard metal.    (2)

3.2    What is the purpose of the heat treatment of steel?    (2)

3.3    Give TWO reasons for tempering hardened steel.    (4)

3.4    Describe how the following heat treatment processes are carried out on steel:

     3.4.1    Annealing    (3)

     3.4.2    Hardening    (3)
     **[14]**

**QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)**

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (4.1 to 4.14) in the ANSWER BOOK, e.g. 4.15 E.

4.1 The purpose of conducting a compression test for an internal combustion engine is to test the pressure in the …

A cylinder.
B oil pump.
C fuel pump.
D radiator. (1)

4.2 Which ONE of the following equipment is used to test the exhaust gases of an internal combustion engine?

A Torsion analyser
B Pressure analyser
C Gas analyser
D Combustion analyser (1)

4.3 The function of the crankshaft in an internal combustion engine is to convert the reciprocating motion of the piston into a … motion.

A linear
B horizontal
C vertical
D rotary (1)

4.4 Which ONE of the following firing orders is applicable to a V6 internal combustion engine?

A 1-5-3-6-2-4
B 1-4-2-5-3-6
C 1-4-2-6-3-5
D 1-5-6-3-4-2 (1)

4.5 An important factor that determines the thermal efficiency of an engine is the …

A size of the carburettor venturi.
B design of the intake manifold.
C combustion chamber's design angle.
D valve opening. (1)

4.6     The total volume that the piston displaces when the piston moves upwards, is referred to as the…

        A     compression volume.
        B     clearance volume.
        C     piston volume.
        D     swept volume.                                                                        (1)

4.7     What will be the mechanical efficiency of an engine if the brake power of the engine is 65 kW and the indicated power is 80 kW?

        A     81,25%
        B     1,25%
        C     1,25 °C
        D     81,25 °C                                                                             (1)

4.8     Which ONE of the following safety procedures must be adhered to when a cylinder leakage tester is used on an internal combustion engine?

        A     Use water to remove dust around the spark plug area.
        B     Do not exceed the prescribed pressure in the cylinder.
        C     Make sure the high-tension leads to the spark plugs are connected.
        D     Exceed the prescribed pressure in the cylinder.                                      (1)

4.9     Which ONE of the following is the cause of low oil pressure in an internal combustion engine?

        A     Combustion chamber volume
        B     Too much oil in the sump
        C     Worn oil pump components
        D     Too large engine capacity                                                            (1)

4.10    Which ONE of the following statements defines the caster angle on a motor vehicle's suspension?

        A     The distance between the front and rear ends of the wheels
        B     The angle formed between the perpendicular line and the centre line of the king-pin as seen from the side
        C     The angle formed between the perpendicular line and the centre line of the wheel as seen from the front
        D     The angle formed between the perpendicular line and the centre line of the king-pin as seen from the front                          (1)

4.11    Which ONE of the following terms describes the condition when the impeller of a torque converter rotates at maximum speed and the turbine is almost stationary (standing still)?

    A    Torque speed
    B    Engine speed
    C    Stall speed
    D    Acceleration speed                                                        (1)

4.12    Which gear is the outside gear in an epicyclical (planetary-) gear train?

    A    Planetary pinion
    B    Ring gear
    C    Sun gear
    D    Annulus                                                                     (1)

4.13    What does the abbreviation *MAP* stand for in terms of the air-induction sensor as part of the engine control system?

    A    Main absolute pressure
    B    Manifold absolute pressure
    C    Mass absolute pressure
    D    Metered absolute pressure                                                  (1)

4.14    Which ONE of the following is the purpose of the brake bands in the three-speed automatic gearbox?

    A    To drive the sun gear from the planetary gear carrier
    B    To hold the secondary sun gear and the planetary gear carrier respectively
    C    To activate the smooth transfer of power flow
    D    To drive the plates of both clutches to rotate with the turbine        (1)

**[14]**

**QUESTION 5:  TOOLS AND EQUIPMENT (SPECIFIC)**

5.1     FIGURE 5.1 below shows a cylinder leakage tester. Answer the questions that follow.



**FIGURE 5.1**

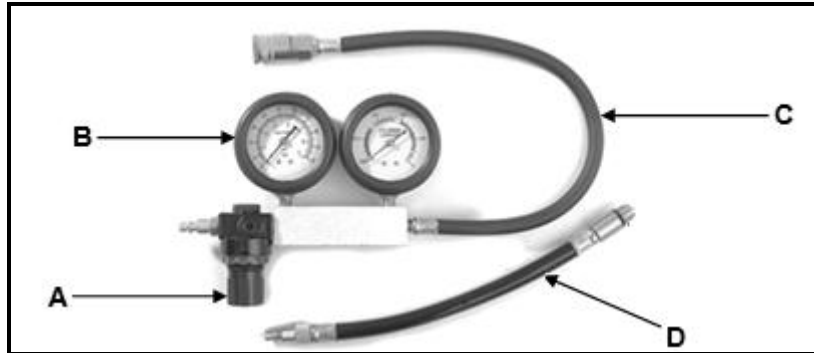5.1.1     Label **A–D**.                                                                                (4)

5.1.2     What is the purpose of the cylinder leakage tester?                   (2)

5.1.3     State, in the correct sequence, the set-up procedure of the cylinder leakage tester on an internal combustion engine.        (6)

5.2     With the reference to the engine cylinder compression tester:

5.2.1     What is the purpose of conducting an engine cylinder compression test?                                                                 (2)

5.2.2     State ONE purpose of the pressure relief valve in the compression tester.                                                              (2)

5.3     Name TWO gases that the exhaust gas analyser analyses.              (2)

5.4     What is the purpose of the turn tables with reference to the wheel alignment equipment?                                                           (2)

5.5     State THREE outcomes of dynamic wheel balancing.                       (3)
                                                                                                          **[23]**

## QUESTION 6:  ENGINES (SPECIFIC)

6.1    State TWO main causes of crankshaft vibration in an internal combustion
       engine.                                                                        (2)

6.2    FIGURE 6.2 below shows a component that is fitted to the front of the
       crankshaft in an internal combustion engine. Answer the questions that
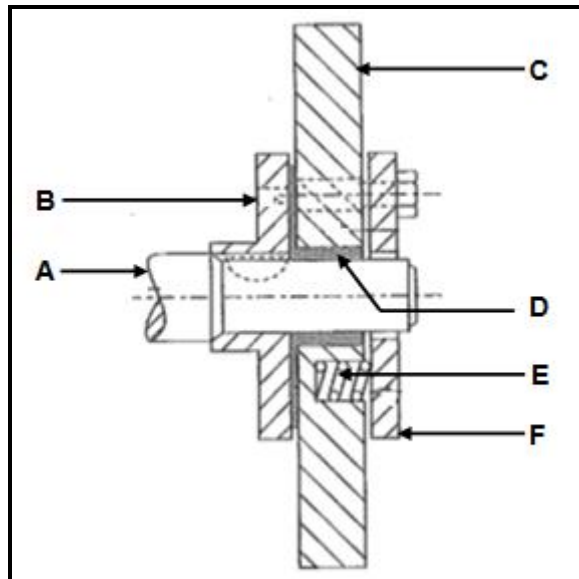       follow.



**FIGURE 6.2**

      6.2.1      Identify the component shown in FIGURE 6.2.                           (1)

      6.2.2      Label **A–F** of the component above.                                (6)

      6.2.3      What is the function of the component above?                          (2)

6.3    State TWO factors which determine the firing order of an internal
       combustion engine.                                                             (2)

6.4    At what angle are the crankpins of a V8-cylinder engine situated?              (1)

6.5    Why is an intercooler fitted to a turbocharged diesel engine?                  (1)

6.6    What is the purpose of a supercharger on an internal combustion engine?        (2)

6.7    FIGURE 6.7 below shows a type of supercharger/blower. Answer the questions that follow.
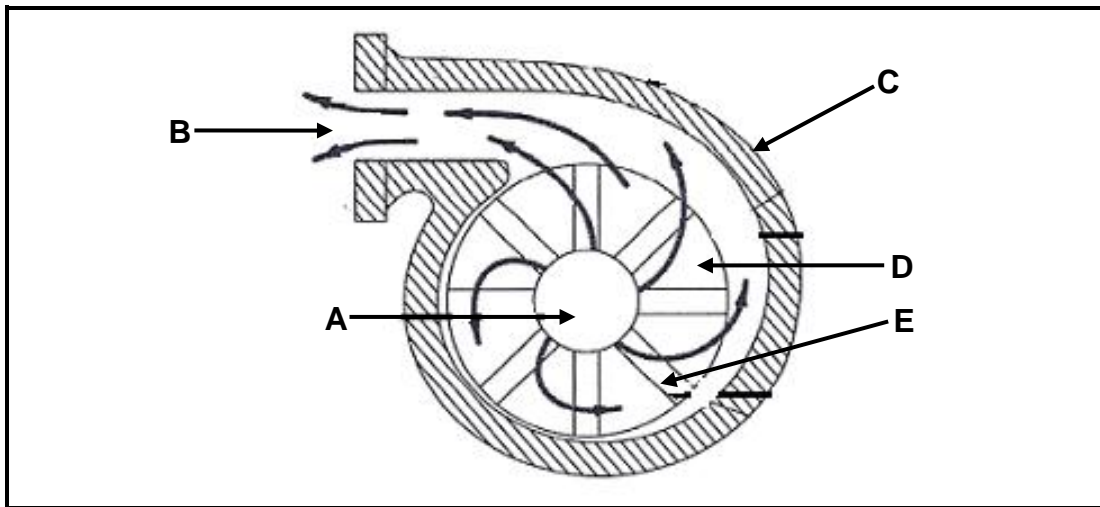


**FIGURE 6.7**

6.7.1    Identify the type of supercharger/blower in FIGURE 6.7 above.    (1)

6.7.2    Label **A–E** of the supercharger/blower above.    (5)

6.7.3    Explain the operation of the supercharger/blower above.    (5)

**[28]**

**QUESTION 7:  FORCES (SPECIFIC)**

7.1 Define *swept volume* in an internal combustion engine. (2)

7.2 State THREE methods that can be used to increase the compression ratio of an internal combustion engine. (3)

7.3 The bore and stroke length of an internal combustion engine are 90 mm and 100 mm respectively. The compression ratio is 10,5 **:** 1.

Calculate:

7.3.1 The swept volume of a single cylinder in $cm^3$ (3)

7.3.2 The original clearance volume of a single cylinder in $cm^3$ (3)

7.3.3 The compression ratio is increased to 11 **:** 1. What will the new bore diameter be if the clearance volume remains unchanged? Answer in mm. (6)

7.4 The following data refers to a four-stroke, four-cylinder petrol engine:

- Engine speed during the test: 4 500 r/min
- Mean effective pressure: 1 300 kPa
- Bore diameter: 120 mm
- Stroke length: 160 mm
- Torque: 610 Nm @ 4 500 r/min
- Number of cylinders: 4

Calculate:

7.4.1 Indicated power in kW (5)

7.4.2 Brake power in kW (4)

7.4.3 Mechanical efficiency of the engine (2)

7.5 Define *mechanical efficiency* of an internal combustion engine. (2)

7.6 Define *brake power* of an internal combustion engine. (2)

**[32]**

**QUESTION 8: MAINTENANCE (SPECIFIC)**

8.1 Explain the procedure used to test the radiator cap by using the cooling system pressure tester. (5)

8.2 State TWO possible causes and TWO corrective measures for pressure drop on the tester used on a radiator or expansion tank of the cooling system on an internal combustion engine. (4)

8.3 State TWO manufacturers' specifications that could be used to conduct a cooling system pressure test. (2)

8.4 State FOUR safety measures while setting up a compression tester on an internal combustion engine. (4)

8.5 TABLE 8.5 below shows information regarding the results of the gas analysis of an internal combustion engine.

Complete TABLE 8.5 by giving ONE cause and ONE appropriate corrective measure for EACH fault.

Write only the answer next to the question numbers (8.5.1 to 8.5.6) in the ANSWER BOOK.

| FAULTS (DEFECTS) | POSSIBLE CAUSES | CORRECTIVE MEASURES |
|---|---|---|
| High carbon monoxide (CO) reading | 8.5.1 | 8.5.2 |
| Low carbon dioxide ($CO_2$) reading. | 8.5.3 | 8.5.4 |
| High hydrocarbon (HC) reading | 8.5.5 | 8.5.6 |

**TABLE 8.5**

(6)

8.6 State TWO manufacturers' specifications that could be used to conduct a fuel pressure test on a motor vehicle's fuel system. (2)

**[23]**

**QUESTION 9:  SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)**

9.1      State ONE purpose of an automatic gearbox in a motor vehicle.        (2)

9.2      State TWO advantages of a vehicle fitted with an automatic gearbox.        (2)

9.3      State TWO disadvantages of a vehicle fitted with an automatic gearbox.        (2)

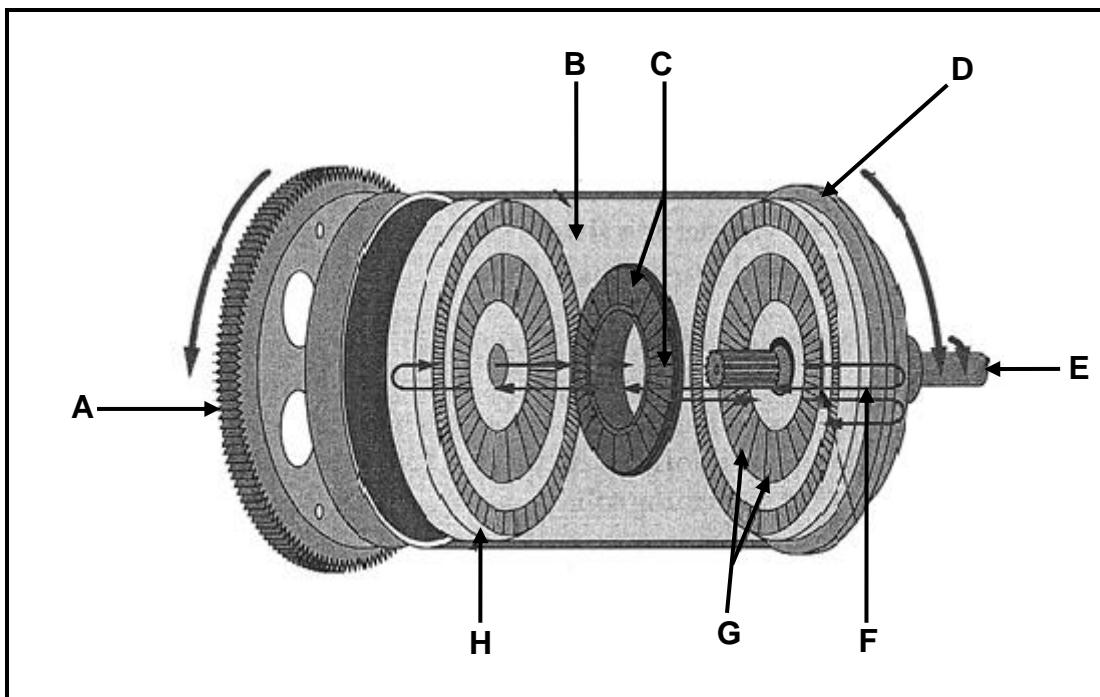9.4      FIGURE 9.4 below shows the operation of a torque converter. Answer the questions that follow.



**FIGURE 9.4**

9.4.1      Label parts **A–H** of the torque converter above.        (8)

9.4.2      State TWO advantages of the torque converter.        (2)

9.4.3      What happens to the torque multiplication when speed increases in a torque converter?        (2)

**[18]**

**QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONICS) (SPECIFIC)**

10.1 State ONE cause of the following tyre wear:

    10.1.1 Feathering (1)

    10.1.2 One side of the thread worn excessively (1)

10.2 State TWO requirements of a well-designed steering mechanism. (2)

10.3 FIGURE 10.3 below shows the king-pin inclination on the suspension of a motor vehicle. Answer the questions that follow.
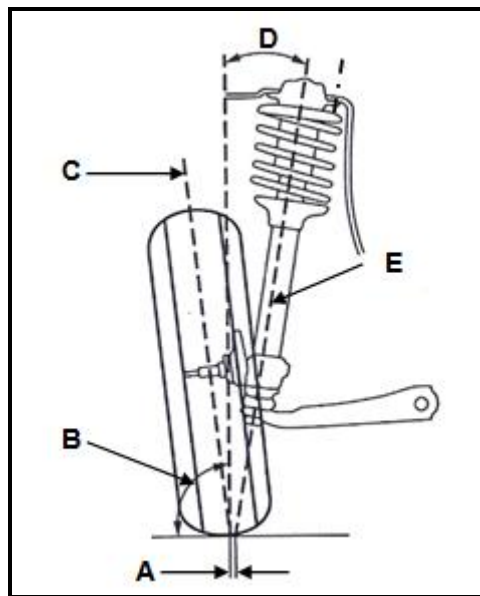


**FIGURE 10.3**

    10.3.1 Label **A–E**. (5)

    10.3.2 Define the *king-pin inclination*. (2)

10.4 Use a labelled sketch to show the Ackermann angle layout. (6)

10.5 What is the purpose of toe-out on turns? (2)

10.6 State TWO checks on a wheel BEFORE it is balanced. (2)

10.7 What is the purpose of the catalytic converter fitted to the exhaust system of a motor vehicle? (2)

10.8 State THREE main aims of the adaptive speed control system. (3)

10.9 What is the function of the slip-ring and brush assembly on an alternator? (2)

10.10 Draw the symbol of a diode that shows the direction of current flow. (2)

10.11 State TWO advantages of an electrical fuel pump on the fuel system of an internal combustion engine. (2)

**[32]**

**TOTAL: 200**

**FORMULA SHEET FOR MECHANICAL TECHNOLOGY (AUTOMOTIVE)**

$\text{Force} = m \times a$

Where : $m = \text{mass}$

$a = \text{acceleration}$

$\text{Work} = \text{Force} \times \text{Displacement}$

$\text{Power} = \dfrac{\text{Force} \times \text{Distance}}{\text{Time}}$

$\text{Torque} = \text{Force} \times \text{Radius}$

$IP = P \times L \times A \times N \times n$

Where $IP = \text{Indicated power}$

$P = \text{Mean effective pressure}$

$L = \text{Stroke length}$

$A = \text{Area of piston crown}$

$N = \text{Number of power strokes per second}$

$n = \text{Number of cylinders}$

| | |
|---|---|
| $BP = 2\pi NT$ | $BP = \dfrac{2\pi NT}{60}$ |
| Where $BP = \text{Brake power}$ | Where $BP = \text{Brake power}$ |
| $N = \text{Revolutions per second}$ | $N = \text{Revolutions per minute}$ |
| $T = \text{Torque}$ | $T = \text{Torque}$ |

or

$\text{Brake power using Prony brake} = F \times 2\pi R \times N$

Where $BP = \text{Brake power}$

$F = \text{Force}$

$R = \text{Brake arm length}$

$N = \text{Revolutions per second}$

$\text{Mechanical Efficiency} = \dfrac{BP}{IP} \times 100\,\%$

$$CR = \frac{SV + CV}{CV}$$

Where CR = Compression ratio

SV = Swept volume

$$SV = \frac{\pi D^2}{4} \times L$$

Where L = Stroke length

D = Bore diameter

CV = Clearance volume

$$CV = \frac{\pi D^2}{4} \times L$$

D = Bore diameter

L = Clearance in mm